Early Warning Systems and Resilience: A Quest for Equilibrium

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Early Warning Systems and Resilience: A Quest for Equilibrium

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Abstract: This communication aims to answer to the following research question: "How can Early Warning Systems support the production activity and make it resilient?" Based on an ethnographic case study, we display that even a simple tool can be helpful for a CEO. We assess that the resilience comes from a well-balanced combination of a qualitative human management and of an analytical system. This equilibrium depends on the fit between the task, the system and the user.

Keywords: Early Warning Systems, Task-Technology-Fit Model, Resilience as performance.

1. Introduction

August 2010, a team of scientist in Honolulu Island have proposed a system that could early warn authorities of an incoming asteroid[1]. This is an example of the use of an early warning system which participates to the global resiliency of planet earth. The links between such a system and resilience is the core of this communication. We try here to answer to the following research question:

How can Early Warning Systems support the production activity and make it resilient?

This question is of managerial and theoretical interest. The first interest relates to indicate to top manager that EWS are an essential component of their strategy. The theoretical interest concerns the use of a validated model in this specific field. The use of Task Technology Fit model for EWS is new and can be the foundation for future studies.

To address our research question, we conducted a qualitative study based on a longitudinal case study.

First we would like to define the meaning we give to the term of resilience. This term has been often used during the last years. Originally coined in physics, resilience signifies that a material

[1] http://www.msnbc.msn.com/id/38791514/ns/technology_and_science-space/

can resist to an impact. Resilience means robustness and not the capacity to regain his previous form after a crash. Then psychiatry has used this term in order to define the capacity of someone to reintegrate into society after a trauma (Cyrulnik, 2004). But for many, this concept is not the concern of science but of journalism. This concept was used for example by Honoré de Balzac : "events are never absolute.. misfortune is a springboard for skilled man and an abyss for a weak man...[2]." However, resilience can be considered as a powerful metaphor and can be applied to many situations. Among the different approaches the one initiated by K. Weick and K. Suttcliffe seems relevant (Weick & Sutcliffe, 2007). This approach mixes organizations, reliability (resiliency) and anticipation. The concept of High Reliability Organization seems close to resiliency and implies that an HRO must anticipate future disaster in order to avoid them. This can be the role allotted to Early Warning Systems. In brief, we assess here that resilience can be seen as the long term performance of a company facing a turbulent environment.

This paper is divided into four parts. Section 2 presents a review of the literature, setting the background for our research question. Section 3 describes the methodology and section 4 details the insights obtained from the case study. Section 5 provides an answer to our research question and conclusive remarks.

2. Theoretical background

2.1 Task Technology Fit

Defining the origin of models built on "fit" in management science is not easy due to a vast number of ways of understanding what "fit" is As Venkatraman & Camillus (1984) mentioned: "*the concept of fit rooted in the population ecology model and in the contingency theory has the central thrust to the development of middle range theories in many management disciplines*". Accordingly, we consider the research work of Burns and Stalker (1961) as the starting point of this concept. Seeking to analyze fit in line with the contingency theory, Drazin and Van De Ven proposed three different conceptual approaches of fit: selection, interaction and systems (Drazin & Van De Ven, 1985). Operating a choice between these approaches necessarily affects fit definition. In this paper, we are close to the system approach, where fit "*is the internal consistency of multiple contingencies and multiple structural characteristics; it affects performance characteristics*" (p. 515).

Investigating the nature of fit, Venkatraman (1989) classified six perspectives of fit, naming each one precisely: Moderation, Mediation, Deviation, Gestalts, Covariation and Matching (p. 425). Assessing that decision making is the result of recognition of a situation, "*Fit as gestalt*" matches with the situation where a decision maker faces a system in order to decide.

Now, we are going to review briefly the Task-Technology Fit (**TTF**) models. Developed in the early 90's, they aimed to explain individual performance related to Information Technologies' usages. Theorized by Goodhue & Thompson (1995) technology is considered as a mean allowing individual to carry out a task. Measurement of performance is based on user evaluations of differences in fit before and after technology implementation (Goodhue, Klein, & March, 2000).

TTF model is still up-to-date and useful, and a recent study demonstrated the importance of 'task-technology fit' in explaining IS continuance intentions (Larsen, Sorebo, & Sorebo, 2009). As confirmed by Zack (2007), "*the notion that technology should fit the task has become an accepted approach to evaluating the performance impacts of information technology*" (p. 1671).

[2] "La comédie humaine »

As a result, many researches are based upon the TTF approach to analyze the interplay between decision making performance and technology. In 2000, Todd & Benbasat (2000) described a model linking a decisional task, a decision maker, a specific technology (a decision support system) and decision performance. This model is one of the first which clearly focuses on decision making performance. Few years later, Jarupathirun & Zahedi (2007) explored the influence of perceptual factors in the success of web-based spatial decision support system (SDSS). Finally, Junglas and al. (2009; 2008) built their studies on the healthcare industry on the TTF perspective. They combined seven notions of fit and four human drives in two original research models which examine the determinants of decision to utilize or not mobile technologies.
In this communication we will based our work on this main idea of fit as displayed below:

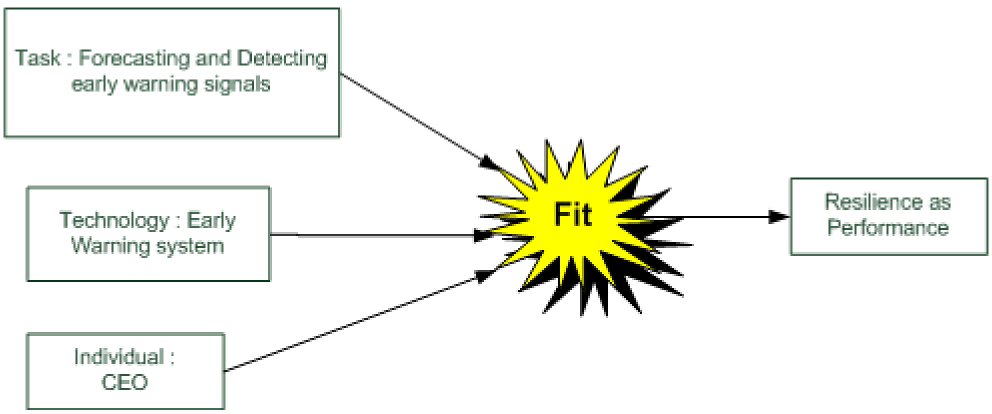

Chart 1 : Fit and Resilience

2.2 Early warning signals and early warning systems

Since antiquity, decision makers always seek to know the future and to discern what will happen in the coming time. They used to consult the oracles…*In a way, it has become a holy grail to come up with ways to identify … and to predict (E. Brahm*[3]*)*
In the early 1950s the RAND researcher James Lipp led Project Feed Back, made a passionate case for the feasibility of a reconnaissance system in which orbiting television cameras would transmit back to earth electronic data, giving the Air Force real-time images of enemy assets.
The organization's studies in infrared detection … led directly to the space-based early-warning system against Soviet attack. RAND researchers verified by calculation that sensors could detect the exhaust plume of a rocket sitting on a launch pad (Campbell, 2004).
The theoretical part seems very simple: every event is a concatenation of many precedent causal events. Thus $Event_n = E_{n-1} \circ E_{n-2} \ldots \circ E_2 \circ E_1$
So if someone is able to detect En-1 before En occurs he is able to foresee that E_n is going to happen, and so on…
F.E.W.E.R. (Forum on Early Warning and Early Response) gives the following definition : early warning is "the systematic collection and analysis of information … and therefore the mission is

[3] http://www.beyondintractability.org/essay/early_warning/

a) to anticipate the process … b) develop strategic responses c) to present policy options … to facilitate decision making (Schmid, 1998).

In matter of fact, many authors get to confusion between Early Warning and Early Response. Thus we can read *"Considering early warning, it is fruitful to divide it into two parts… first, there is a goal of collecting data… second… there remains the task… to act"*[4].

Three parameters seem to be a must: 1) Permanent structure to collect and analyze data and at what level the alert should be given, 2) A signal is to be transmitted to the decision-makers, 3) Requirement to network synergy (CRP, 2004).

Douglas considers that there are three key steps in the process[5]:

- Decide what to measure (build a data base)
- Build the measuring systems (transmission to decision makers)
- Establish an interdisciplinary monitoring team (Network synergy)

There is however an important gap between the useful decision-relevant knowledge and its use by decision makers: at present, early warnings are rarely early, seldom, accurate, and moreover lack the capacity to distinguish.

Factually, there are two dimensions in EWS. The Microeconomic and operational dimension led, later on, to a Macroeconomic and political dimension.

This is why it seemed interesting for us to present an experience that has integrated these elements in a simple and effective way to optimize the couple (quotation, added value) in a real case study. By forecasting the orders flow and level, the CEO can adapt the minute cost used for quotation in order to maximize the machines load and/or the total added value.

3. Research Method

We have performed a longitudinal case study. That means that we have observed the same elements over the period of 3 years. It can be considered as an ethnographic research as we have been embedded in the field as the main actor (Myers, 1999; Schultze 2000). In order to avoid distortion, the first author has been out of this field and has interviewed the second author in order to gain in objectivity.

In addition there have been two techniques:

- Participant Observation
- Interviews and talks between the two authors.

We have used the primary data (interviews and talks) and secondary data (about the French industry of paper and about other similar case studies).

In regard with epistemology, we can say that we follow an interpretive approach (Klein & Myers, 1999). Interpretive studies generally attempt to understand phenomena through the meanings that people assign to them and interpretive methods of research in IS are "aimed at producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context[6]. That's why we have given a relatively good image of the cognitive biases in this study. Because biases have to faces: they can lead to failure,

[4] http://www.clingendael.nl/cru/pdf/early.pdf

[5] http://www.evancarmichael.com/Leadership/5155/3-Keys-to-Effective-Early-Warning-Systems.html

[6] http://www.qual.auckland.ac.nz/

but they are essential for making complex decision and to select one early signal among the others.

4. The case of PNR company

4.1 Context of the company

The Internet-driven dematerialization has not led to the elimination of paper use. Although the paper industry in France has been jostled, it has achieved a turnover of nearly 5 billion Euros according to the INSEE.
The paper converting companies provide a finished good from a raw material: paper. The finished good is manufactured through successive industrial stages: printing, cutting, folding and gluing paper. In this document, we focus on a specific type of paper product: the envelopes; and we describe three successive TTFs (Task Technology Fit), each linked to the precedent and built on it to lead to a more elaborate technology based on the “Bootstrapping” technique.

4.2 The company, the product and the market.

The manufacture of envelopes can be done via two major processes: the first consists in the production of "format" envelopes, cut out in paper reams with die cutters, then placed in special machines that print, fold, and glue the obtained cuts to shape the final envelope; the second is a more modern method which takes the production directly from the paper reel to the envelope machine, which cuts the paper and successively completes all the processes of printing, folding, and, most importantly, gluing.
PNR is the name of the company that we describe. PNR has forty machines, of which, one third use the “paper rolls start” method and two thirds use the “format start” method. The company has a turnover of 40 million Euros and a cash flow that fluctuates between 0.5 and 2 million Euros.
The products themselves are divided into two main families: the "standard" products including the envelopes of the catalogue, the most common and most frequently requested. This family of products is called "stock envelopes". On the other hand, there are the envelopes manufactured to special sizes, special prints and even special papers requested by customers.
Normally, "stock" envelopes have price grids allowing the company to issue quotations based on the requested quantities. However, "special" envelope orders necessitate a calculation of the product cost price. Thus, a "gamut" is created and a cost is established. The "gamut" is developed by three technicians and quotation makers. It specifies the format and quantity of paper, the cutting tool, the printing and the window if needed, the packing boxes, the machine to be used, the appropriate amounts of material, the cost of each stage of the process, and finally, the total cost of production.

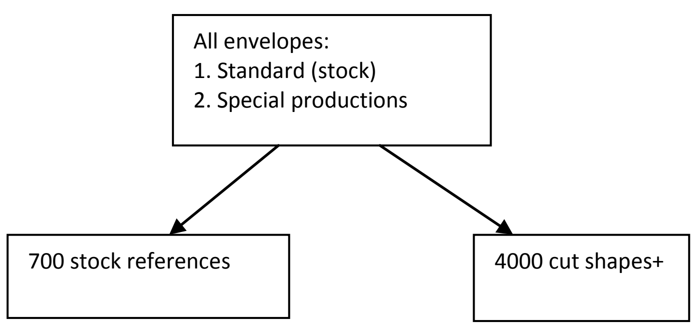

Chart 2 : major “format” envelopes in stock and special productions

The sales team is composed of fifteen sales executives visiting customers and making new prospects. They report to the Sales Administration Department which consists of a dozen of people.
The sale of items in stock (700 References) accounts for half of the turnover, i.e. € 20 million and the sale of special items accounts for the other half.
When a client requests a quotation from a sales executive, the latter could refer to the price grid and issue a very fast quotation. However, if the request is for special size and/or printed envelopes, he has to go through the quotations department.
These quotation makers process about 17 to 20 quotations a day. The quotations department constitutes a bottleneck, since its three members are the only ones well acquainted with all the cutting tools, the cost of ordering a new cutting tool, and the formats of the paper used. They are also the "Guardians of the Temple" similar to what number of industrial companies have to face.

Task one: From basic data to database

We had to get rid of this bottleneck for three major reasons: guarantee a fast response to clients, process a greater number of quotations per day, and make the quotations processing easier. This triple task necessitates sharing basic data among all the concerned persons. For this reason, we decided to use a database technology. The database management software "Oracle" was selected, and within four months, a software company set up an operational system that allows finding out the references of all cutting tools available forms as well as all paper formats. The quotation department, having participated in setting up this database, found it a perfect answer to its needs.
Naturally, we were able to expect from the three persons working at the quotations department to issue a greater number of quotations per day. Indeed, the effectiveness of this first technological step allowed us to move from 17 to 30 quotations per day.

Task two: From a database to a quotation making engine

This advance, while interesting, is not satisfactory, since PNR has over 2,500 customers and cannot be limited to thirty quotations per day. Our minds then began to dream of an "engine" that automatically calculates the quotation. But the task did not seem very easy.
Then came a long weekend, and thanks to a simple spreadsheet, an approximation of the cost price was applied to a number of highly demanded stock items, which production costs were very well known. Step by step, tricks for prices approximation were discovered which allow the establishment of credible cost. These approximations considered the surface of paper required to make an envelope, the type of machine, the quantity of glue and ink to be used, as well as the boxes and pallets required.
Then, the cost price of number of references was calculated, using the approximate calculation system which had been designed. It appeared that this simulation yielded a cost approaching 10% of the real cost. After about 72 hours of hard work, numerous cups of coffee, and the reprimands from the wife... the core of an "engine" or automated computing system was born. It was immediately dubbed ACCOT (for ACcelerated COtation).
After this long weekend, the newly developed basic system was proudly saved on a disk and sent to the controller to be tested.
The controller's response didn't come fast ... Two weeks later, the controller showed in the General Management office, with his eyes somewhat tired, but with a further elaborated system. This new system was less approximate than the first, used the (Paradox) database, and led to cost prices calculations approaching the calculations of the Quotations Department specialists by 5%.
This new technology was tested on a consistent set of quotations, to validate its ability to provide sufficiently accurate quotations. The quality, reliability, economy, ease of use and ultimately the adequacy of the system were no longer doubtful.

A special effort was then devoted to developing a more complete version of ACCOT. Two months later, the new calculation system gave a cost that was almost identical (± 2%) to that obtained after many calculations by the Quotation Department.
People in the sales administration were not easy to convince, because putting both the customer contact and the quotations making in their hands, would give them more power, but also more responsibility. Gradually, the idea grew bigger, and the number of quotations grew by seven, from 30 to 200 quotations per day. Thus, the quotations department disappeared and the staff was redeployed to operational tasks where it can be useful. Three positions were reduced in parallel.

Task three: building an early warning system (EWS)

But, as time passed, and the number of quotations grew, a first evidence appeared: a strong growth of quotations occurring in one moment, used to lead, a few days later, to an increase in orders; and a momentary decreasing in the number of quotations resulted, a few days later, in taking less orders...
Thus, we asked the Controller to collect statistics on the number of quotations submitted and the number of confirmed orders and to transform the figures into curves. It became clear that there was a definite correlation between the number of quotations and the number of confirmed orders. It even appeared that the average time elapsed between the quotation issuing and its confirmation was 4 to 5 days. The following chart gives an idea of the relationship between the two curves.

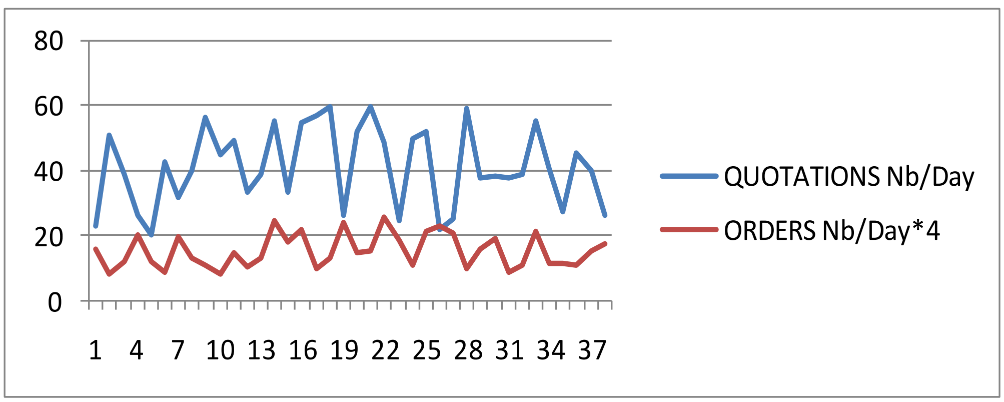

Chart 3 : Correlation between quotations and orders

Therefore, it was easy to assume that from the number of "quoted" envelopes, it was possible to deduce the number of envelopes that were likely to be ordered within four to five days.
We then asked the Management Control Officer to add to the number of confirmed orders the number of potential orders extrapolated from the number of quotations.
Thus the following spreadsheet was elaborated. It is updated daily by the Management Control Officer:

Machine Type	Number of weeks Actual orders	Number of weeks Potential orders	Provisional machine loading in number of weeks
Envelope reel	2	1	**3**
Pockets reel	3	2	**5**
Format envelopes	1	0	**1**
Format pockets	2	1	**3**
Printing	1	0	**1**

Table 1 : Machine Load spreadsheet

In the light of this spreadsheet, we can know the potential load per production line. This charge is partly certain and partly potential. But, knowing the future machinery load, we have the power not only to consider, but also to modulate the sales behaviour in order to take advantage of the obtained forecasts.
Nevertheless, ACCOT uses the cost per minute of each machine to calculate a quotation. This is why we had the idea to try to run, at the highest level of the company, the modification of the cost price parameters, depending on the machine load of the firm.
As a result, we built a system that allows us to modify, up or down, the cost per minute of a given production line: up to the overloaded line and down to the under loaded one. Of course, before applying these new parameters, we check the validity of the suggestions on a weekly basis, depending on exogenous parameters (elections, strikes ...).

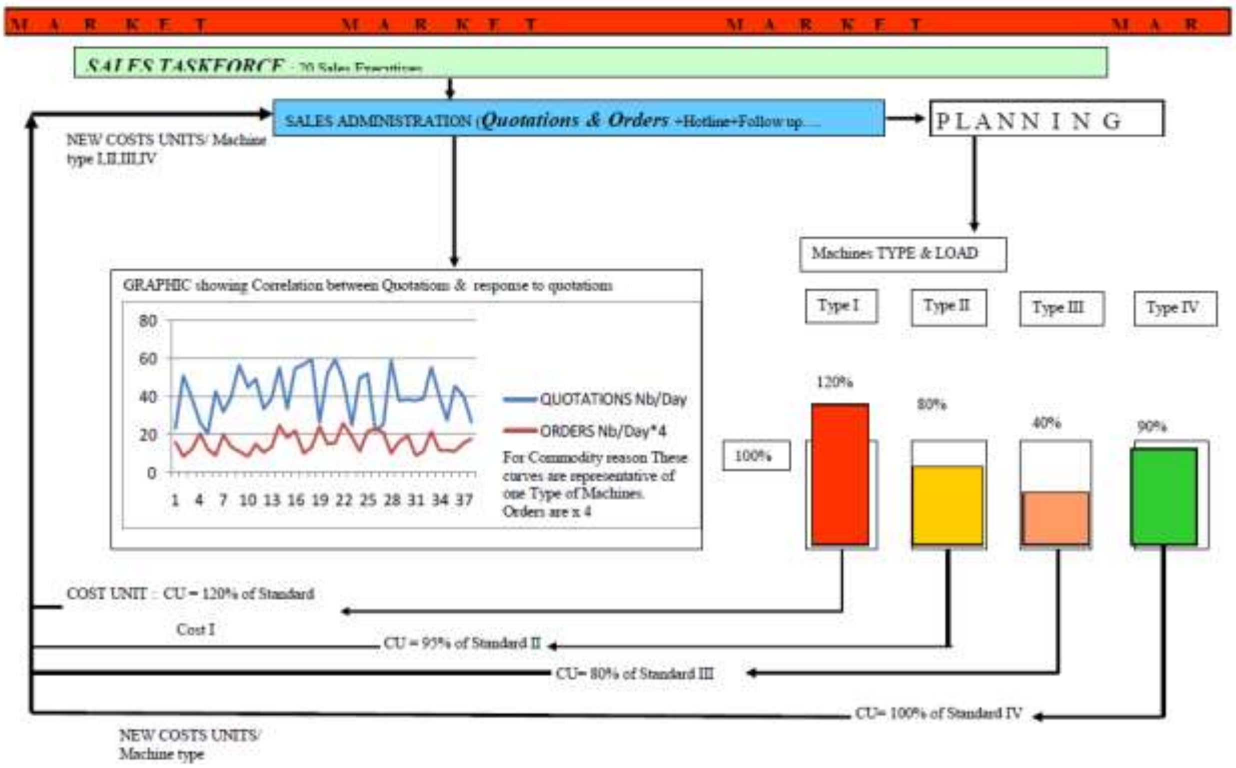

Chart 4 : TOTCOM: a system of cost ADEQUATION to the market demand

A true early warning system (EWS) and a true Early Response System (ERS) was thus born. It was called TOTCOM (TOtally COMmercial) in honor of sales people and to show them that the whole company was mobilized to push them to work miracles...
TOTCOM has been an essential element that allowed the company to increase its market share from 12% to 21% of the local market.

4.3. Lessons

Thus, three successive technologies have enabled us to answer three important tasks:
1- A technology of referencing all format tools and paper through a database, which allows easier access to data and practically doubles the number of manually calculated quotations.

2- A technology of quotations processing "engine", which optimizes the task of quotation makers and multiplies the number of quotations by 7 and reduces three job positions.
3- An Early Warning System technology (EWS) and Early Response System (ERS) that allows modulating the apparent cost price in order to optimize the increasing of the orders margin produced on loaded lines and load the under-loaded lines by lowering their apparent cost price.

5. Result and Discussion

This case study displays what we can call a perfect fit between the task, the system and the user. But we have to go deeper in the concept of "fit" itself in order to draw lessons from this case.
We can display the three following elements:
1. A co-built fit.
That means traditionally there is independence between the task, the user and the system. But here, we have seen a slow process for building a system that will obviously fit the expectancies of its designer. That process has two main implications:

- Trust (Jones, 2002): the user will trust his tool and base his judgment on the data displayed. This is the positive aspect.
- Cognitive bias (Kahneman, Slovic, & Tsversky, 1982; Turpin & du Plooy, 2004): Two biases can have an influence here. First, the illusion of control, this well known cognitive bias can give the CEO the feeling that with this "perfect tool", he totally manages the situation. Therefore, this tool offers a simplification of the reality and has not passed a hard test. The second bias is "anchor and adjust". That means that the CEO could focus on the data displayed and try to find a solution only near these data avoiding any more creative solution. This can be seen as a negative part, but we assess that it is not. The reason is that these biases are inherent to this close relation between the system and the CEO.

2. Fit as a gestalt
That means that there are no quantitative criteria that can be used to determine if there is a fit or not. The CEO feels that it fits because the image given by the EWS is suitable for him. That can lead to another cognitive bias: overconfidence (Rai , Stubbart , & Paper 1994).
3. Shift of the frontier between human and machine
The arrival of a decision support system tools always shifts the frontline between the decision maker and his tool. But here, it's a bit different, as the CEO has designed the EWS, we can say that he is a part of the EWS. That means that the frontier has moved but not so far as usual. Building a system in his own image could be the source of another bias: conformation bias. In short, there is a risk that the system gives the information the CEO wants reinforcing the idea that this system is reliable.

As a global result, we can say that the EWS has many flaws coming mostly from the fact that it has been designed by its main user. But this is too the reason of its success. So that implies that a pretty poor and simple tool can be a success and be and aid for the global resiliency of a company. In introduction we have stated the following research question: "How can Early Warning Systems support the production activity and make it resilient?" We can answer our research question by saying that the resilience comes from a well-balanced combination of a qualitative human management and of an analytical system. This is a classical result, but we propose that this equilibrium depends on the fit between the task, the system and the user. That means that the EWS must be created or largely customized by the CEO. This is particularly true in the case of this specific task of detecting early warning signals. In this case, cognitive biases will be inevitable. The talent of the CEO will be to be aware of these biases and to keep a certain distance with the data given by its system.

This communication has two implications. From a theoretical aspect, linking Fit, cognitive biases and resilience can be the foundation from an adapted TTF model. The main contribution is that the strength of the fit is more important than the intrinsic quality of the technology. In short, it means that it's better to have an adapted but simple system than a powerful tool. It can lead to weight the components of TTF model. This can be done with a more quantitative study. For the practical implications, it can explain the failure of Executive Information Systems. Ten years ago, this kind of systems seemed to be the solution for supporting strategic decisions of CEO (Clark, Jones, & Armstrong, 2007; Watson, Rainer Jr, & Koh, 1991). One main characteristic of these systems was that they were easy to use. But the ease of use was from the viewpoint of software designer. Nowadays, this term of EIS has nearly disappeared. We think that it is because CEO must be involved in the design of his tools. We are back on this idea of co-built fit. We think that it is a necessary condition of success for such support systems tools.

Finally, this study has many limits. First, it is an ongoing study we have to go deeper in order to better describe the relations between the EWS and the CEO. Second, we have to generate a global model and to test it on other cases. Third, we have to better insist on the specificities of the domain of early warning signals.

We have begun this communication with the example of an early warning system based in Honolulu. We just can hope that this system is not too complex, give a place to cognitive biases, in short, that it fits well with his users.

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